used for dose measurements in the build-up zone for megavoltage photon beams. The study focused in ultrathin thermoluminescent (TL) detectors with an effective point of measurement (EPOM) smaller than 5 mg/cm^2, Gafchromic films (EPOM~120 mg/cm^2) and a novel plastic scintillator detector (EPOM ~0.8 g/cm^2).

Materials and Methods: Two types of ultrathin LiF:Mg,Cu,P-based TL dosimeters (MCP-Ns from TLD Poland and TLD-2000F from Conqueror Electronics Technology Co. Ltd.), EBT2 Gafchromic films (Ashland) and an Exradin W1 plastic scintillator (Standard Imaging) have been tested against the results of a PTW-Freiburg 23392 extrapolation chamber (EC), entrance window ~0.7 mg/cm^2. The experimental measurements were also compared with Monte Carlo dose calculations with the PENELOPE/penEasy code.

All the studied detectors were used to measure the dose at build-up region and in particular the surface dose on a plastic water™ phantom for 6 and 15 MV photon beams from a Varian Clinac 2100 C/D, 10 x 10 cm^2 field-size and SSD=100 cm. The percentage depth-dose distributions were measured with EBT2 films and Exradin W1 scintillator detector. The phantom consisted of 30× 30 cm^2 slabs with thicknesses ranging from 0.1 to 5 cm. In all cases, for each depth at least three measurements were taken and the experimental set-up was repeated in three different days. Regarding the EC measurements, a special support made of wood was constructed and successive depths were measured by adding the corresponding plastic water slabs over the entrance window of the chamber while fixing the SSD to 100 cm. For three electrode separations, three measurements were made at the positive and negative voltage bias and the corresponding average was calculated.

Results: Monte Carlo simulation results were in good agreement with the EC measurements (average differences < 2 %). Among the tested detectors, ultrathin TLD's showed the best accuracy for surface dose estimations (within statistical uncertainties, 3% 1 SD). The correction factors for surface dose determination with the other detector types ranged from 0.3 to 0.8. Regarding dose measurements in the build-up zone, Gafchromic films results were in good agreement with the EC measurements (average differences <2 %) with the exception of the surface dose. As expected due to its effective point of measurement, the Exradin W1 overestimated the surface dose and its results were in agreement with the EC measurements (within 5%) for depths beyond 5 mm.

Conclusions: Although extrapolation chambers are the most suited detectors for build-up measurements for megavoltage photon beams their use is not practical. Among the tested detectors, ultrathin TLD's and Gafchromic films showed a good accuracy for dose measurements in the build-up zone. In particular, ultrathin TL detectors are the detector of choice for surface dose measurements.

PO-0843

Hot-spot analysis for incident detection in real-time 3D EPID-based in vivo dosimetry

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Purpose/Objective: The goal of real-time 3D in vivo dosimetry, which we are currently capable of, is to prevent serious injuries to patients during radiotherapy by automatically halting the linac in case of uncorrectable dose deviations. These are, however, not well-defined. This study is exploring a new way of dose verification, called hot-spot analysis (HSA), which has been directly derived from a possible definition of an uncorrectable dose deviation. The parameters and alert criteria for HSA are of paramount importance: false positives would be detrimental to treatment throughput and may cause anxiety. False negatives, on the other hand, would defeat the purpose of real-time verification. By retrospectively analysing a large number of in vivo dosimetry measurements using HSA, we aim to determine its usefulness for clinical implementation of real-time 3D dosimetry at various alert levels. Note that real-time dosimetry is not intended to find smaller, correctable deviations.

Materials and Methods: An uncorrectable dose deviation is defined as a local overdose which would induce unacceptable toxicity to the patient. Note that it is not assumed that the patient's setup is correct; hence, any such local overdose is regarded as an uncorrectable dose deviation regardless its actual position. In accordance with this definition, HSA seeks hot spots in the delivered dose distribution, defining a hot spot to be a volume with a certain minimum diameter and a minimum local overdose (MLO) within a region of interest (ROI) – the volume enclosed by a predefined isodose level in the delivered dose.

In this study, a minimum diameter of a hot spot of 17 mm, corresponding to a volume of 5cc, was used and two ROIs were evaluated: defined by the 1 and 2 Gy isodose surfaces. To obtain insight in the distribution of deviations, the threshold MLO is varied from 2 – 100%, allowing in the most extreme case a single-fraction overdosage of 4 Gy. HSA was then used to re-analyse reconstructed 3D dose distributions of 1095 randomly selected incident-free treatments given in 2013, all of which had been verified (offline) using our 3D EPID-based in vivo dosimetry method. For each treatment and each set of HSA parameters, the presence of hot spots was determined.

Results: Table 1 shows for both ROIs the number of treatments having at least one hot spot as a function of threshold MLO; the distribution of positive alerts is clearly not normal. Individual inspection of these alerts is ongoing, but seems to indicate that either they are not big enough to be considered as an incident alert, e.g. for the low MLO values, or are caused by limitations of our 3D dose reconstruction model.

Table 1. Number of positive alerts per MLO and ROI.

	number of positives (absolute and relative)			
MLO (%)	*100cGy ROI*		*200cGy ROI*	
0	1095	100%	1095	100%
2	785	72%	631	58%
4	715	65%	502	46%
6	639	58%	420	38%
8	573	52%	355	32%
10	512	47%	297	27%
20	323	29%	147	13%
30	219	20%	88	8%
40	154	14%	59	5%
50	120	11%	41	4%
75	71	6%	17	2%
100	46	4%	14	1%

Conclusions: HSA is a useful method for detecting uncorrectable dose deviations derived from a clear clinical motivation. As such, it is a promising method for detecting deviations relevant to real-time dosimetry. However, the current number of false alerts is still too high for direct clinical implementation.

PO-0844

Feasibility of in vivo dosimetry using diodes in breast treatments delivered using a SIB-IMRT technique

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Purpose/Objective: Entrance dose i*n vivo* dosimetry (IVD) using diodes is an end-to-end QA procedure that is widely used in conventional radiotherapy treatments. However, in advanced delivery techniques, such as SIB-IMRT, the reliability of this QA procedure is controversial. We developed a reliable QA procedure for breast treatments delivered using a SIB-IMRT technique based on IVD using diodes.

Materials and Methods: We calibrated 6-12 MV QED diodes (Sun Nuclear) using an emX electrometer (IBA) in terms of entrance dose at SSD = 90 cm and field size = 10 cm x 20 cm (average conditions for IMRT breast treatments). We measured correction factors for distance, field size, obliquity, and MLC transmission. We planned 14 SIB breast treatments using 6MV x-rays and 7-9 sliding window IMRT fields (TPS: Eclipse, algorithm: AAA v8.9; Varian). Determining entrance dose points is challenging due to fluence modulation, and also to patient contour irregularities, beam obliquity and tissue heterogeneities. To minimize these challenges, we calculated all treatment fields at 0º gantry angle, maintaining the SSD, on a regular water phantom. For each field, we recorded entrance dose (at maximum dose depth) at two points: on the central axis and on the region of highest fluence. Treatments were performed using a Clinac 2100C/D equipped with a Millenium 120 MLC and the RPM system (Varian) for respiratory motion management. We placed one diode at each of the aforementioned points on the patients' skin. We assessed clinical uncertainties by placing the diodes at the same position but on a Plastic Water phantom (CIRS), and irradiating them under the conditions used for entrance dose calculations. To ensure positioning accuracy was lower than 0.5 cm, we attached a template which projected a 1 cm square grid at isocenter to the collimator using an add-on. We compared IVD measurements with the calculated entrance doses.

Results: The table shows the average difference between measurements and calculations, excluding doses below fixed thresholds. Consistency improved by increasing the threshold because we excluded false positives due to non-significant dose contributions. Although agreement between in-phantom measurements and calculations was excellent, in patients we observed larger differences and variability due to positioning inaccuracies (figure). The table shows the two-fold tolerances which provided >95% of acceptable IVD assessments.

Table. Average differences between all in-phantom and patient measurements with respect to calculated entrance doses. The two-fold tolerances apply to: (a) both diodes of the same field, and (b) averages of all differences per patient.

Entrance dose threshold (Gy)	Average difference ± 1 SD (%)		IVD tolerances (%)	
	Phantom	Patients	(a) per field	(b) per patient
0.05	−0.2 ± 8.7	−1.6 ± 15.3	17.4	4.9
0.10	0.0 ± 8.4	−2.1 ± 14.1	16.0	4.3
0.20 (figure)	0.3 ± 7.4	−1.3 ± 13.4	15.3	3.6

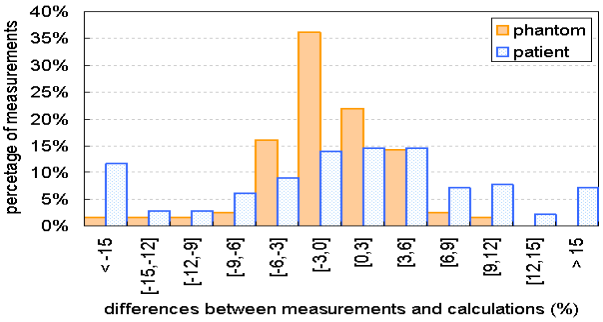

Figure. Histogram of the differences (in %) between measurements and calculated entrance doses (excluding doses below 0.2 Gy).

Conclusions: IVD using diodes is a feasible QA procedure for breast treatments delivered using a SIB-IMRT technique. We propose using two diodes per field in high-fluence regions (entrance dose >0.2 Gy). We suggest a two-fold tolerance for IVD assessment (95% confidence limits): a dose difference of 15% for both diodes per field, and an average difference of 3.6% including all measurements per patient.

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PO-0845

Development of methodology for remote IMRT audits and related tests

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Purpose/Objective: A co-ordinated research project (CRP) is under development and implementation within a collaborative multi-centre effort. The aim of the CRP is to broaden the portfolio of dosimetry audits offered to radiotherapy centres by national audit networks operating in middle and low income countries. Moreover, the inclusion of